INCREASED STIFFNESS OF VEHICLE STRUCTURE IN ACCIDENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part application of co-pending international application number PCT/DE 96/02120 filed Nov. 7, 1996 and claiming the priority of DE 19543706 A1 filed Nov. 17, 1995. This PCT/DE 96/02120 (WO 97/18984) is revised and refiled

- 06/03/97 and 07/08/97 for the purpose of amending the drawings, description, claims and contesting the prior art ref. to the German examination report of 09/09/96 and PCT search report of 03/24/97;
- 12/09/97 in order to correct and list the opposed prior art documents DE-OS 4342038 A1, DE-OS 2162071, U.S. Pat. No 4,307,911 (DE 3103580 A1), U.S. Pat. No. 3,819,228, EP 0423465 A, EP 0642940 A (Patent family member U.S. Pat. No. 5,518,290), EP 0659601 A and DE 3726292 C1 in compliance with the PCT rules ref. to the preliminary PCT examination report of 10/02/97 and
- 12/07/98 in order to correct and list the opposed prior art documents U.S. Pat. No. 3,788,686, U.S. Pat. No. 3,819,228, U.S. Pat. No 4,307,911, U.S. Pat. No 4,676,524, U.S. Pat. No 5,306,067, U.S. Pat. No 5,806,917, DE-OS 2405875 and DE 4240416 A1 ref. to U.S. examination report of 10/14/98.

The abbreviations DE and EP denote the German Pat. Application or Document and European Pat. Appl. or Doc., which will be omitted hereinafter.
All mentioned Pat. Appls./Docs, a 53-page report to the EU-Commission, US-, Canadian and Japanese Ministries for Transport, all accident reports by newspapers, German Police and the inventor listed in the Chap. "OTHER PUBLICATIONS" are parts of submittal.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates generally to vehicle door, more particularly, to its supporting door frame in co-operation with interlocking assemblies of the compound assemblies (see Chap "Definition" and Claim 1) in order to properly engage all series-connected doors with the vehicle roof and side rail (sill portion) disposed along the vehicle floor, all post sections (pillar portions) and the peripheral edges of vehicle body (passenger compartment or cell), when the vehicle door is in closed position, thereby distributing energy to those vehicle parts, lowering stress thereof whilst avoiding passenger ejection and enhancing survival chance in the event of any collision (front, side and/or rear collision) and/or rollover (overturn).

2. Discussion of the Prior Art:

In order to formulate in single terminology a generalized definition for the proper term is presented:

Definition:	**Proper Term:**
"*all series-connected doors*"	one or arbitrary (generally) series-connected doors of each vehicle side
"*girder*"	panel, shell, beam etc. according to FEM and Technical Mechanics

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#10
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Objection to the patentability of US. 5,806,917
Examination report of Oct. 8, received Oct. 22
Patent Appl. No. 08/860,182
PCT/DE 96/02120 (DE 195 43 706 A1)
my 3-page fax plus two enclosures of 11/06/98

Dear Mr Morrow, 12/15/98

Fatality of a driver of BMW's convertible car [10] is evidence for the failure of BMW's US 4.676,524 which is significantly improved by MB's 5,284,360. Owing to attached MB's DE 4344604 C1 the construction of MB's roof is stiffened, however, the reinforced roof of MB E320 [12] was totally deformed due to lack of *reliable* interlocking assemblies.

The PCT/DE96/02120, EP 0869878 B1, CA 2,220,872 and US 08/860,182 consists of the Appl. DE 19543706 and extended Appl. DE 19645925. Both German Application Forms are attached

Allow me please to compare your objections to my terms in my previous patent application with those of US Patent attorneys

your objections said	US Pat. Nr common use in US Pat. Docs	my new terms I've totally eliminated
passenger compartment	Porsche's 5,562,329 e.g. in Abstract, pp. 1/col. 25, 46 etc. Porsche's Attorneys have completed the Patent Docs. of BMW, MB etc.	vehicle body despite the proper words "passenger compartment" (cell).
door truss		door frame
means	Claims of 4,307,911	none
title comprising two to seven words	10 words in 4,307,911	exactly seven

I appreciate your correct objections to some Figs., which must be denoted by "Prior Art", Claims, violating the USPTO-Rules, but not German, European Patent-Rules.
I may refer to the correct words of "form-locking connection", explained in Chap. "Noteworthy" in pp. 5 and my skill as one the most talented Attorney confirmed by the

examiners of German Patent and European Patent Office granting patent on the following within short period of 11 months:

- enclosed European Patent 0869878 B1 (family member of US 08/860,182, CA 2,220,872), EP 0844939 B1,
- DE 19615785 C1, DE 19636167 C1, DE 19711392 C1, DE 19549378,
- DE 197 49 780, 197 58 497, 197 58 498, all these three must be amended for the purpose of patent-granting upon receiving the official examination reports.

What is the use of securing the service of US Attorneys, who would use phraseology violating the USPTO-Rules and need my teachings? This is the reason why the examiners of the German Patent, European Patent Office and WIPO have taught me to formulate Claims etc. in order to save their life upon implementation of my inventions in cars, trains and aeroplanes. Please read my enclosed report [1] and the reply of NHTSA [19] thereon. However, I do have secured the help and service of an Oxford Graduate Stuart Forbes in order to have phraseology in compliance with Oxford English.

The claim 32 corresponds to claim 20 of the EP 0869878 B1, whose total claims of 35 were requested on the enclosed registered letter of Dec. 15, 97 to EP Office.
Would you help me to amend my new patent appl. in compliance with USPTO-Rules in order to amend my other pending US- patent appls.?
Thank you for your help and efforts in advance.

I may wish you Merry Christmas and Happy New Year.

Sincerely

Dr. Go

Attached:
European Patent 0869878 B1 (family member of US 08/860,182)
letter of Dec. 15, 97 to EP Office to request the permission for claim 20
new patent appl., Figs., all publications, claims in double-space lines, disk
US 5,284,360, DE 4344604 C1
German Application Form of DE 19543706 and extended Application Form of DE 19645925

I've already mailed to you the following appls/docs:

DE 19543706 A1 (*1)	Germany	11/17/95
DE 19645925 (*2)	Germany	11/07/96
DE-PS 1755661	Germany	06/06/68
DE-OS 2162071	Germany	12/24/70
DE 3103580 A1	Germany	01/07/82
DE 3726292 C1	Germany	02/23/89
DE 4342038 A1	Germany	12/09/93
EP 423465 A	Europe	10/18/89
EP 642940 A (*3)	Europe	09/09/93

PCT/DE96/02120 is based on Patent appl. (*1) and extended Patent appl. (*2).
(*3) patent family member US 5,518,290

"*window-guide elements*" of vehicle doors	window-guides **6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB**
"*door cavity*"	space between the outer and inner panel of the door
"*door detachment*"	vehicle door becomes detached from the vehicle body
"*mating parts of interlocking assembly* (engaging pair)	interlocking mating parts of an interlocking assembly such as key & receptacle, interlocking hook & interlocking recess, interlocking hole & interlocking block or interlocking hook & interlocking rod
"*interlocking hole*"	interlocking aperture, interlocking slot, interlocking oblong hole
"*compound assembly*"	two vehicle mating parts, such as vehicle door & vehicle roof, vehicle door & side rail, vehicle door & peripheral edge (transition region), vehicle door & post section/s, vehicle door & vehicle door, vehicle door & vehicle body in engagement in the event of any collision and/or rollover

It is known in the prior art to provide interlocking assemblies to engage and/or clamp the vehicle door with the other vehicle parts, when the vehicle door is in closed position, thus distributing energy, lowering stress whilst enhancing survival chance only in the event of either mid-front collision or side collision of type U2, one of four types shown in **Fig.** 13. However, all these conventional configurations do not take into account the failure of passenger protection due to the following problem cases in conjunction with disengagement of the mating parts of interlocking assemblies from each other in the event of all types of real collision (any real collision) and/or real rollover:

- **A** Load cases **I to V** according to Technical Mechanics/FEM in real front, side and rear collision;
- **B** Wrong assumption of the prior art for the purpose of idealizing a general side energy S or S_1 to a single energy S_x or S_{x1};
- **C** Analogy between the state of non-contact and disengagement;
- **D** Constant, small contour-clearance and assembly tolerance zones;
- **E** Large tolerances of interlocking assemblies;
- **E1** The first inventions of interlocking assemblies, huge production costs and fatal injury in real collision due to large tolerances;
- **E2** Large deformation of vehicle structure or door **8. 8B** in real collision;
- **E3** Large deformation of side rail **18** in real collision;
- **E4** Large deformation of upper door frame **8.17** and vehicle roof **17** in real collision;
- **E5** Intrusion of vehicle roof **17** in vehicle body **20** in real rollovers; and
- **E6** Clamping assemblies or adjustable interlocking assemblies to resolve problem case **E**.

Evidence for failure of the prior art, resulting in door detachment associated with passenger ejection and intrusion of vehicle parts and/or power plant (drive assembly) associated with severe/fatal injuries, is listed in the 53-page report [1] for the purpose of minimizing injury-severity level, number of injuries and injury-related costs, over $ 1 billion per day, in real accidents of vehicles world-wide, some of which, having always achieved very good to best verdicts in the front crash tests, are German and Volvo cars known world-wide as the safest. NHSTA [19] has confirmed the correctness of the theses and commitment therefor.

Problem case **A**: In order to idealize an impact force $2F_1$ in **Fig. 10A** imposed on a vehicle structure the following assumptions must be specified:

- let the vehicle structure be idealized by two symmetric vehicle halves subjected to an front impact force 2F along the centre line.

Load case **I** in z-y plane in **Fig.** 5: The moment $M_x = H^*h$ about the x-axis is replaced by a pair of forces $H_A = (H^*h)/l$ with the lever arm of l. Employing the equilibrium condition for moments two forces of reaction are obtained: $V_A = (V^*l_C)/l$ and $V_B = -V_A + V$. Acting in z-direction with respect to the sign are three shear forces: -V, $(H_A + V_A)$ and $-(H_A + V_B)$. Under load of these forces the vehicle side, comprising all post sections, series-connected doors **8, 8B** reinforced by impact elements and interlocking assemblies of those doors and post sections, is subjected to the bending moment along the y-axis.

Load case **II** in z-x plane in **Fig.** 6: The force V exerts bending moment M_{zx} along the x-axis and rotating moment $M_y = V^*b$ about the y-axis acts as torsional moment along the vehicle side.

Load case **III** in x-y plane in **Fig.** 7: The A-post section is under load of rotating moment $M_{xy} = -H^*b$. The vehicle side is subjected to bending moment M_{xy} along the y-axis and buckling force H.

Subjected to the total stress of bending moments M_{zx}, M_{xy}, M_{zy}, buckling force H and torsional moments M_z, M_y in the load cases **I to III**, the vehicle side in **Fig. 8** is deformed in real front collision.

By reversibly disposing the series-connected doors **8, 8B** the same load cases are obtained for real rear collision.

Load case **IV** in x-y plane in **Fig.** 9: Under load of side impact energy S at impact angle α 27° according to FMVSS 214 or in the event of real side collision the vehicle side is subjected to bending moment M_{xyS} along the y-axis and lateral force S_y.

Load case **V** in z-x plane in **Fig.** 10: Under load of side impact energy S at impact angle γ or in the real side collision against a tree or highway column **22** in **Fig. 10A, 13** the vehicle side is subjected to bending moment M_{zxS} along the z-axis and lateral force S_z.

The total stress consists of the stresses in load cases **IV** and **V**.

Problem case **B**: With the exception of DE 4342038 A1, the prior art is governed by the following assumptions:

- let tolerances between interlocking mating parts of an interlocking assembly be neglected and
- let the load cases **IV** and **V** be idealized to a lateral energy S_x in **Fig. 9** or S_{x1} in **Fig. 10A** imposing on the *centre* of vehicle door, illustrated as collision type U1 in **Fig. 13**, despite four collision types U1 to U4 [15] and the collision type U2 having the highest percentage of severe and fatal injuries. Nevertheless, car manufacturers and suppliers world-wide have adopted this idealized S_x or S_{x1} in inventions e.g. U.S. Pat. No. 4,307,911, U.S. Pat. No. 5,806,917, U.S. Pat. No. 5,518,290 (EP 0642940 A, DE 3934524), whose shortcomings are mentioned in the following problem case **E2**.

Problem case **C**: As exemplified in [2], reproduced in **Figs.** 11, 12, both end coils of compression-coil spring **19** are guided by two spring seats **19.1**. Their utmost outer nodes KN_1 and KN_{End} (not drawn) rest against both stops **19.3**, where i represents the number of coils. To survey the rolling behaviour of end coil **19** on the lower spring seat **19.1** the end coil is idealized in elements by supporting springs in reference to the nodes and by the threshold value of the distance in the "state of rolling" $s < 0.1$ mm. **Fig.** 12, [2] illustrate the rolling behaviour in regard to the FEM data and test results marked with M in dependence on $F_z = -790$, -1000 and -3000 N:

- According to test results KN_2 to KN_5 roll on the spring seat at $F_z = -790$ N, but in the state of non-contact at $F_z = -1000$ and -3000 N.
- According to FEM data the nodes in the following states are in dependence on F_z:

F_z	State of contact	State of rolling
-100	KN_1, KN_{15}, KN_{17}	KN_1 to KN_3, KN_{10} to KN_{18}
-250	KN_1, KN_{19}, KN_{20}	KN_1, KN_{15} to KN_{23}
-1415	KN_1, KN_{17}, KN_{19}, KN_{20}, KN_{30}, KN_{31}, KN_{33}, KN_{34}	KN_1, KN_{15} to KN_{35}

When both end coils roll on the mating spring seats upon increase of energy, some nodes/elements thereof, previously in the state of contact, are in the state of non-contact. Analogously, interlocking assemblies are exposed to the disengagement.

Problem case **D**: Recently in automotive industry, great efforts have been made to achieve (finish) a constant (uniform), small contour clearance [16] between the outer door-contour "abcde" of vehicle door **8, 8B** and the door aperture of vehicle body **20** in **Fig.** 5. in order to minimize flow noise and, particularly, to achieve sales success in co-operation with an overall impression of attractive design. In the state of assembly the contour clearance e.g. of AUDI ® vehicles is only 2.5 mm and of VW Passat ® 3.5 mm, 0.5 mm less than Japanese vehicles according to VW CEO Dr. Piëch [17].
For the purpose of automatic assembly with the above-mentioned goal, a device ref. to DE 3726292 C1 determining six reference points on the outer door-contour calculates the differences between the outer door-contour and the door aperture (opening) of vehicle body **20** within the assembly tolerances by assembly, disassembly and assembly of the same vehicle door in **Fig.** 18.

Problem case **E**: The position D_l of latch mechanism **248**, rigidly attached to vehicle door **8**, and the position B_l of striker **298**, rigidly attached to post section illustrated as B-post section in **Fig.** 10A of U.S. Pat. No 4,307,911 representing the prior art, is provided with locking tolerances (clearances) in x-, y- and z-direction, thus ensuring the state of door locking and the normal operation of vehicle door. For the purpose of preserving the constant, small contour-clearance,

- the position D_a to D_c of each key **128a to 128c**, rigidly attached to vehicle door **8**, and the position S_a to S_c of mating receptacle **158a to 158c**, rigidly attached to lower reinforcing panel **156** of side rail **18**;
- the position D_n of key **148**, rigidly attached to vehicle door **8**, and the position B_n of mating receptacle **198**, rigidly attached to post section,

must be provided with position-tolerances, **larger** than locking and assembly tolerances, in x-, y- and z-direction in order to avoid

1. interference with the locking operation of latch mechanism **248** to striker **298** when closing vehicle door **8**;
2. expensive reworking at the assembly line;

3. customer complaints due to disturbing noises [3]. Due to the small distances of overlaying coils denoted as $w \leq 0.2$ mm in **Fig.** 11, noises such as rattle etc. [3] occur at different oscillations when driving. This condition is comparable with the distances of the mating parts of interlocking assemblies to each other; and
4. high reject rate due to different references of coordinate system of vehicle door, finished by two to three suppliers and transported to assembly line, and of vehicle body **20**, finished at the assembly line. Huge costs are necessary to computerize design data of vehicle door and structure in data files, which must be evaluated by innovative programs to minimize those position-tolerances and reject rate, however, under the condition of the constant, small contour-clearance.

Noteworthy: A pin, in free connection with a king-size hole, under load can never engage therewith due to large tolerance. A prerequisite for engagement is small tolerances (clearance) of mating parts in x-, y- and z-direction. Examiners of German and European Patent Office as well German and European engineers classify such engagement or connection governed by small tolerances as form-locking connection.

Problem case **E1**: According to the first invention of the largest German Corp. having over 100 years of experiences of building luxury cars ref. to DE-PS 1755611 of 06/06/68, the taper-formed key **148** and the mating receptacle **198** should be in engagement or form-locking connection ("Verbindung" in Claim 1) to ensure energy-transmission from one post section to the other.

Because receptacle **198** and striker **298** are formed together in one piece, an adjustment of receptacle **198** changes the position of striker **298** to the latch mechanism **248** as well as the clearance therebetween, which becomes too large or small. In order to properly latch and lock the vehicle door to vehicle structure the "interlocking" assembly is provided with large tolerance zones, thus violating the condition of the aforementioned feature.

When a luxury vehicle [11] of this Corp. driven on a slippery icy road laterally crashed against a truck, the key **148** disengaged from mating receptacle **198** due to large clearance so the remaining energy totally deformed the vehicle door, whose intrusion fatally injured the driver.

At the end of the 80's the Corp. decided to stop the production of over 20 million "interlocking" assemblies, wherewith over five-million vehicles had been equipped within two decades. A problem of two tolerance zones remains unresolved and is very costly.

According to the second invention of the 2nd largest Japanese car Corp. ref. to DE-OS 2162071 of 07/06/72 in **Fig.** 1A, contour tongues **16.1** should be in engagement with contour grooves **16.2** in order to integrate vehicle door **8, 8B** into side rail **18,** vehicle roof **17** and B-post section in side collision. Without "interlocking" assembly of the vehicle door and B-post section, the normal operation of vehicle door would be possible if the outer door-contour "abcde" were square. Regarding the recent contour design in **Figs.** 5 and 18 the line "ab" is generally curve-shaped, line "bc" of front door upwardly inclined ($\beta > 90^0$) or generally curve-shaped and line "bc" of rear door generally S-shaped, so contour grooves **16.2** would interfere with contour tongues **16.1** when closing the vehicle door.

Furthermore, to sustain large impact energy it is necessary to reinforce the wide contour groove by an element which, unfortunately, can't be attached to the narrow upper region of door frame **8.17**.

If this invention were really useful, why had the Corp. not implemented it in each of two sport utility vehicles, whose vehicle structure collapsed and steering column intruded into vehicle body **20**, in 40 % offset crash test [1] at low speed of 50 km/h conducted by ADAC?

According to the first U.S. Pat. No. 3,819,228 of the largest Italian car Corp. of 06/25/74 a bulky "interlocking" bolt rigidly attached to a reinforcing inner panel of vehicle door **8** projects through a hole of a stiff element attached to side rail **18** when the door is in closed position. The problem of large tolerance zones remains unresolved. Moreover, the overall stylish impression spoilt by a bulky "interlocking" bolt will, doubtless, not be beneficial to sales. When stepping in or out of the vehicle body while cleaning or repairing, the person can injury himself when stumbling over this bulky interlocking bolt. When closing the door the danger of damage to clothing and injury to passengers, particularly when it is dark, is apparent

If this invention were really useful, why had the Corp. not implemented it in the latest compact car, whose vehicle structure collapsed in a real front collision [14] and in 50 % offset crash test [1] at low speed of 55 km/h conducted by Auto Motor und Sport, wherein the femur force of 15100 N would fracture both legs?

Problem case **E2**: Both luxury cars [6, 7], a convertible car [10], U.S. Pat. No. 5,518,290 (EP 0642940, DE 4330620) and U.S. Pat. No. 4,676,524, which are described in this Chap., belong to a well-known car manufacturer having HQ in South Germany.

All four passengers, where one of them was instantly dead at the accident site, were hurled out of a brand-new luxury car [6] colliding into a tree in Wiesbaden City and rolling over. Under load of force F_1 in **Fig.** 10A the deformation of vehicle structure, particularly in y-direction, was **larger** than that of each vehicle door whose catching **hook 148**, rigidly attached to impact beam **1, 1B**, and latch mechanism **248** were disengaged from the mating recess **198** and striker **298**, all of which were arranged to post section.

In a real side collision of another luxury car [7] manufacturer into a tree, great energy totally deformed the vehicle side whose intrusion fatally injured both passengers. Obviously, the lateral force, deviating from the idealized force S_{X1}, could not force catching hook **148** to penetrate into recess **198** in order to define an "interlocking" assembly ref. to U.S. Pat. No. 5,518,290.

Both real accidents resulting in severe/fatal injuries verify the shortcomings of any patent valid only for survival chance under load of an idealized force S_{X1}, denoted by arrow A in Fig. 1 of U.S. Pat. No. 5,518,290. Taken as given, the mid region of door is secured to the B-post section by the "interlocking" assembly in an "idealized" accident, the upper, lower door frame **8.17, 8.18**, the vehicle roof **17** and side rail **18** are overstressed due to lack of interlocking assemblies. Moreover, problem cases **E3 to E6** remain unresolved.

As exemplified by U.S. Pat. No. 4,676,524, a pair of vertically supporting window-columns, rigidly mounted in both vehicle doors **8** of a convertible car is in abutting, "engaging" relationship with both termini of upper member of cowl, when both vehicle doors are in closed position, owing to a pair of "interlocking" assemblies, each of which consists of

1. a receptacle of the terminus of the upper member and a locking mating tip of key of the window-column pressing therein in the first embodiment; or
2. a king-size hole of the terminus of the upper member and a mating key of the window-column having a mushroom-shaped head being in free connection therewith in the second embodiment

for the purpose of enhancing survival chance in rollover.

When the convertible car rolls over,

1. great shear force fractures each locking tip of key; or
2. great impact energy totally deforms each "interlocking" assembly, whose key and king-size hole are in disengagement ref. to Chap. "Noteworthy",

thereby totally deforming the cowl and pair of window-columns.

The stiffness of such open roof of a convertible car [10], merely supported by a pair of post sections in force-locking or free connection with one pair of small-size window-columns, is

- very low, thereby resulting in fatality in a real rollover thereof;
- lower than that of a rotatable, stiff rollover bar ref. to U.S. Pat. No. 5,284,360 (DE 4130470 C1) solely implemented in convertible cars of the largest German Corp.,
- far lower than that of the closed roof **17** supported by two pairs of post sections of the safest sport car [4] ref. to problem case **E6** and
- substantially far lower than that of the roof construction according to the invention ref. to DE 4344604 C1 to reinforce the closed roof **17** strongly supported by three pairs of reinforcing post sections of the safest, top luxury car [12] whose passengers were instantly dead in a real rollover ref. to problem case **E5**.

Problem case **E3**: Due to great energy in a real side collision against column **22** of a central barrier in **Fig.** 10A, 13 on a highway

- **large** deformation of side rail **18** and rear section of a brand-new two-seater German top model [5] of the largest European car manufacturer, opposite to x-direction, caused the disengagement of the driver's less deformed vehicle door **8** from vehicle structure and later on
- the vehicle [5] rolled over three times across the highway and down-hill, thus totally deforming vehicle structure, doors **8**, tailgate-door **8T**, out of which both rear passengers were hurled, and, alternately, opening and closing both vehicle doors **8**, out of which both front passengers were hurled out.

Grass **70** clamped between each post section and each vehicle door **8** in **Fig.** 8 was evidence for the alternate opening and closing of both vehicle doors **8** during the rollovers.

In a side collision of a small German car [8] into a tree great energy totally deformed vehicle door **8** whose intrusion severely/fatally injured the passengers.

In a collision of another car [9] into a hill great energy totally deformed the right side rail **18** thus resulting in the disengagement of the latch mechanism **248** and, if provided, interlocking assemblies too and later on totally deforming vehicle structure during rollover. The driver was hurled out of this car.

Problem case **E4**: In front collision or crash test impact energy deforms, in general, upper door frame/s **8.17** outwards and vehicle roof **17** upwards, thereby creating a gap o in **Fig.** 10A and preventing front vehicle door/s **8, 8B** and/or vehicle roof **17** from transmitting energy to vehicle body **20**.

Three different states of deformation are reproduced in three crash tests, conducted by ADAC, of the German vehicles of the same type [18] 40 % offset crashed at the same speed of 50 km/h against

- a very stiff barrier,
- a deformable barrier and
- another vehicle of the same type

because the uniform load, deformable property of two colliding masses, impact condition etc. are different. The gap o having three different sizes in **Fig.** 8 verifies the above-mentioned thesis of non-transmission of energy.

In side collision impact energy deforms, in general, upper door frame/s **8.17** inwards thereby inflicting injuries on head.

Problem case **E5**: During rollover of the top luxury car [12] of the largest German Corp. several times, impact energy totally deformed vehicle roof **17** whose intrusion severely or fatally injured both front passengers, whose heads were, definitely, crushed by falsely deployed airbags, and the remaining energy totally deformed vehicle body **20** and doors **8, 8B, 8T, 8x**.

Problem case **E6**: Responsive to problem case **E**, a clamping assembly ("Verkrallungspaar"; "Türverkrallung" = door clamping. "verkrallen" = to clamp) of EP 0423465A1 illustrated in **Fig. 1B** comprises

- a stiff hook of reinforcing ledge **25.2** rigidly mounted to lower door frame **8.18** and
- a thin mating panel of a reinforcing plate **25.1**, rigidly attached along reinforcing sill rail **18**, serving as a site of predetermined fracture.

In excess of predetermined value in real side accident, the mating parts **25.1, 25.2** of interlocking assemblies are in the state of clamping to ensure the permanent engagement of lower door frame **8.18** with sill rail **18** in order to resolve the problem of passenger ejection. The proprietor, a German sport-car manufacturer, has built, beyond doubt, the safest sport cars in the world. Load cases **I to III, V** and problem cases **E2 to E5** remain unresolved. Furthermore, there is no space to house both mating parts **25.1, 25.2** in vehicle roof **17** and upper door frame **8.17** subjected to lateral load F_o in real accident. The lack of interlocking assemblies became obvious in the rollover of its classic, very expensive sport car [4], which plunged seven meter downwards and crashed with vehicle roof **17** at a lower level of an underpass in Wiesbaden City thus totally deforming vehicle roof **17**, body **20** and both upper door frames **8.17** during rollover, where the remaining energy was transmitted through both head rests, integrated into the respective vehicle seats, to the vehicle floor, thereby reducing the AIS of both passengers. AIS is an international acronym of Abbreviated Injury Severity ranging from 0 (no injury) to 6 (fatality).

Responsive to problem case **E**, adjustable and/or latching mechanisms are provided for interlocking assemblies ref. to DE 4342038 A1, whose adjustable and/or latchable keys are bolted to the B- or C-post section, facing the termini of both reinforcing beams **1, 7** or **1B, 7B**, and whose mating receptacles are arranged thereto. Both plates **5.1, 5.2** of each hinge of vehicle door are provided with a rivet serving as key and an oblong mating hole. Owing to this feature load cases **I to IV** are resolved, but load case **V** and problem cases **E3 to E5** remain unresolved.

Evidently, due to load cases **I to V** and all problem cases **B, E, E1 to E5** "interlocking" assemblies of the remaining prior art are unsuitable for the purpose of energy-transmission and distribution by means of the integration of vehicle doors **8, 8B, 8T** into the vehicle body **20**, such as U.S. Pat. No. 5,297,841 (EP 0659601 A1), U.S. Pat. No. 4,307,911 characterized with five tolerance zones, U.S. Pat. No. 5,806,917, whose priority date of Dec. 22, 1995 is six weeks later than this present invention, characterized with eight tolerance zones.

Upon reading the report [1] examiners, inventors and accident-experts can perceive the relationship of failure of passenger protection with deficiencies of the remaining prior art.

SUMMARY OF THE INVENTION

Accordingly, the principle object of the present invention is to overcome the deficiencies of the prior art by providing engagement for interlocking assembly having large tolerances, which are necessary in car manufacturing and door assembly, in order

- to protect passengers against ejection from the vehicle body and/or intrusion of vehicle part and
- to increase the vehicular stiffness

in the event of any collision and/or rollover. These interlocking assembly are arranged to the corresponding compound assemblies (vehicle part & another vehicle part).

This principle and other objects of the present invention are accomplished by the following features (proposals):

- clearances (permissible tolerances) by installing and adjusting interlocking parts from outside to guarantee the engagement of interlocking assemblies thereby ensuring the connection of the series-connected doors with all vehicle parts of vehicle body **20** such as post sections, vehicle roof **17**, peripheral edges **21**, vehicle floor, fastened to a pair of side rails **18** facing each other, in any collision and/or rollover;
- interlocking assemblies with adjusting mechanisms such as interlocking holes & interlocking blocks **15.1 to 15.5a**, **15.7**, **15.8**, interlocking hooks **15.6** & reinforcing rod **17.1d** and interlocking holes & interlocking blocks **30 to 37** in **Fig.** 1, 3, 3A, 4, 4A and 14 to 18;
- window-guide elements to accommodate the interlocking parts;
- space-saving, inexpensive design for interlocking parts;
- arrangement of interlocking mating parts of a compound assembly in at least two operating planes;
- arrangement of an U-shaped block having interlocking blocks in the mutual post section of the juxtaposed vehicle doors and interlocking mating holes in both door frames thereof for ensuring the engagement owing to constrained deformation thereof.

Despite the failure of the prior art in the event of real side collision any modification and extra design for survival chance in real collision and/or rollover will generate costs, R&D expenses and weight due to the use of other inventions.

Summary of the advantages of the present invention:

A) saving labour-time by installing and adjusting interlocking parts from outside the vehicle body.

B) low reject rate.

C) space-saving, inexpensive design.

D) dissimilar operating planes or at least two operating planes for each compound assembly to optimize the engagement of its interlocking assemblies in association with energy absorption due to load cases in different planes. **Figs.** 14 to 18 illustrate *a single compound assembly*: window-guide element & B-post section with the interlocking assembly: interlocking blocks **34** & interlocking holes in z-x plane acting as the first operating plane, however, interlocking assembly: interlocking blocks **32, 33** & interlocking holes in z-y plane acting as the second operating plane. The permissible tolerances may be specified from "narrow" to "less narrow", thus cutting costs for the adjustment work. This feature of dissimilar operating planes is applicable too for both interlocking assembly: interlocking holes & **15.1, 15.2a** and **15.2, 15.3** and **15.4a, 15.5** etc. in **Fig.** 3. A row of the same interlocking blocks is operative in dissimilar operating planes by disposing a number of the same interlocking blocks **15.1** to the generally inclined A-post section or of blocks **33** to the generally inclined B-post section. In

reference to the global xyz coordinate system the interlocking block **15.2a** & interlocking hole is operative in an inclined plane.
Because the hinge bolts of the front and rear doors have an operating direction in z-axis the arrangement of interlocking assembly: interlocking holes & blocks **31, 36** to one operating plane is sufficient. However, any additional arrangement of interlocking holes & blocks **30, 35** improves the engagement of vehicle mating parts and substantially decreases fatal injuries in any real collision.

E) minimizing the R&D work by reducing FEM calculations, crash tests and by saving material due to the arrangement of interlocking assembly in different operating planes.

F) passenger protection for all collisions by a **single** construction, manufacturing, testing expenditure, assembly and material supply.

G) exploitation of the peripheral edges **21, 21T, 21h, 21x** of vehicle body **20** provided with isolation material **21.10** in **Figs.** 1, 17, 18 due to the sites to accommodate interlocking parts and the continuous stress curve. The enlargement of the peripheral edges to a limited extent neither impairs the overall stylish impression nor obstructs the passenger from ingress to or engress from the vehicle body. Those edges (regions) of all post sections are defined by the dotted lines "a1", "b1", "b2" and "c1".

H) overall stylish impression. As substitutes of the bulky interlocking bolt ref. to U.S. Pat. No 3,819,228 small-size interlocking parts can be distributed in inconspicuous manner along the window-guide elements as well as peripheral edges, thus substantially ensuring the engagement of compound assembly whilst lowering stress. Due to this feature it is possible to arrange the interlocking parts

- **30, 32, 35, 37** to the respective peripheral edges **21** of vehicle body **20**. In contrary to U.S. Pat. No. 3,819,228, this feature won't endanger passenger when stepping in or out, furthermore, more useful for passenger protection in side collision, particularly, according to collision types U1 and U2 in **Fig.** 13 as well as in front collision.
- **15.2a, 15.2, 15.7** e.g. with screws M4 to the narrow window-guide element **6.3, 6.3B** of upper door frame **8.17** to resolve the problem of the large, stiff contour groove ref. to DE-OS 2162071.
- **33, 34, 36** to the respective window-guide elements **6, 6B** and auxiliary parts **6.7, 6.8** in engagement with the reinforced B-post section in two to three operating planes without obstructing the operation of the seat belt **26.1** in **Fig.** 15. The fact, that no contact is made during the opening operation of series-connected vehicle doors, is demonstrated by the trajectories of both outer points of the washer and of the door edges drawn with dotted lines.
- **31** to the respective window-guide elements **6** and auxiliary parts **6.6a** in engagement with the reinforced A-post section.

I) less stress to solve the problem of total deformation. By means of arrangement of interlocking assembly in multi-operating planes and increase of compound assemblies such as vehicle door & vehicle roof **17**, vehicle door & side rail **18**, vehicle door & post section/s and vehicle door & vehicle body **20** more vehicle parts in compound construction are involved in energy absorption in different load cases in the event of any collision and/or rollover.
In co-operation with DE 4342038 A1 the structural stiffness reaches the maximum. Beyond doubt, the advantage of interlocking blocks *2.1, 5.6* & interlocking mating holes is due to the further exploitation of the very stiff impact beams **1, 7** to house the corresponding interlocking parts. Because the other compound assemblies such as vehicle door & side rail and vehicle door & vehicle roof are not equipped with interlocking assemblies this *single* arrangement of one compound assembly in mid region

of door is insufficient in the event of any collision and/or rollover, therefore endangering the passengers in the following state of deformation

- intrusion of vehicle roof **17** into the vehicle body and of upper door frame **8.17** , thus squashing the passengers and
- buckling of the upper portion of the A-post section, total deformation of upper door frame **8.17**, buckling of vehicle roof **17** and buckling of side rails **18** in **Fig.** 8.

In order to avoid the above-mentioned state a number of interlocking holes or interlocking blocks **30 to 37** is arranged to the peripheral edges **21** *above*, *below* of the impact beams **1, 7** and *therebetween.*

When the *non-adjustable* interlocking rivets *5.6* of the door hinges in x-z operating plane are replaced by a number of interlocking assemblies **15.1, 15.2a, 15.4, 30, 31** in several operating planes, the total stress of the compound assemblies: A-post section & vehicle door along the z-axis is lower owing to stress distribution, thereby preventing, to a certain extent, the A-post section and vehicle door from total deformation and gap o in **Fig.** 8.

J) measures against passenger ejection and total deformation of the vehicle parts, whereby vehicle doors are not or less deformed, in real accident ref. to problem cases **E2 to E4**, which can solely be solved by engagement of the following interlocking assemblies governed by clearances:

- interlocking holes & interlocking blocks **15.3, 15.3a, 15.5a, 15.5** owing to U-shaped blocks **17.3, 18.3**, whose deformation causes a constrained deformation of the juxtaposed vehicle doors, vehicle roof and side rails;
- interlocking holes & interlocking blocks **32, 33, 34, 30, 15.2, 15.4a** of the compound assembly: vehicle door & B-post section in four operating planes; *and/or*
- interlocking hooks **15.6** & reinforcing rod **17.1d** of both compound assemblies: juxtaposed vehicle doors & side rail and juxtaposed vehicle doors & vehicle roof, so that the deformation of the side rail and vehicle roof causes a constrained deformation of the juxtaposed vehicle doors; and

by *energy transmission* into the other vehicle side by means of transverse girders **17.2, 17.2b, 17.2c, 17.2d, 18.2** of vehicle roof, side rails and all post sections facing each other, thus distributing the energy thereto.

K) passenger protection by engagement of vehicle mating parts in rear collision. Door detachment [13] in rear collision occurred due to the lack of door hinges and interlocking assemblies. For the purpose of interlocking of vehicle mating parts the engagement of rear door **8B** with the C-post section is improved by rigidly disposing

- auxiliary part **6.5C**, adapted to the outer door-contour and having interlocking holes to receive interlocking mating blocks **37** in **Figs.** 14, 18, to the door frame of rear door; and
- interlocking blocks **33, 34** to window-guide element **6B**.

The features of vehicle door are, doubtless, suitable for tailgate door **8T**, sliding side door, liftgate door cargo door, trunk cover **8x**, hood **8h**, series-connected doors, e.g. three vehicle doors with four post sections of large van..

BRIEF DESCRIPTION OF THE DRAWINGS

A number of embodiments, other advantages and features of the present invention will be described in the accompanying drawings with reference to the xyz global coordinate system::

Fig. 1 is a side view of vehicle side, body, impact beams, interlocking blocks, interlocking hooks, window-guides and window-guide elements (reinforcing elements).

Fig. 1A is a cross-sectional view of a vehicle door engaging with a roof and side rail ref. to DE-OS 2162071 in side collision.

Fig. 1B is a cross-sectional view of a vehicle door engaging with a side rail ref. to EP 0423465 A1 in side collision.

Fig. 2 is a side view of an U-shaped window-guide element, the position of interlocking blocks **15.7, 15.8** and of an additional window-guide element **6.4, 6.4B**.

Fig. 2A is a side view of an U-shaped window-guide element, the position of interlocking blocks **15.7**.

Fig. 3 is a perspective view of a front stiff door frame with both window-guides, both respective window-guide elements and interlocking assembly of the 1st embodiment.

Fig. 3A is a cross-sectional view of an interlocking block equipped with an adjusting mechanism.

Fig. 4 is a perspective view of interlocking assembly interlocking hooks & reinforcing rod of the 2nd embodiment.

Fig. 4A is a cross-sectional view of the reinforcing rod and the interlocking mating hook equipped with an adjusting mechanism.

Fig. 5 illustrates a load case I in z-y plane in front collision of vehicle.

Fig. 6 illustrates a load case II in z-x plane in front collision.

Fig. 7 illustrates a load case III in x-y plane in front collision.

Fig. 8 is a state of total deformation of vehicle at displacement v in front collision.

Fig. 9 illustrates a load case IV in x-y plane in side collision of vehicle.

Fig. 10 illustrates a load case V in z-x plane in side collision.

Fig. 10A illustrates the mating parts of interlocking assemblies ref. to U.S. Pat. No 4,307,911 (DE 3103580 A1), both mating parts of a latch mechanism, the general force F_1 or S_1 in the event of front or side collision and a highway column.

.Fig. 11 is a view of a compression-coil spring on a lower spring seat.

Fig. 12 illustrates the projection of the end coil and spring seat in a plane, the test results and FEM data of an end coil rolling on the lower spring seat in dependence on load.

Fig. 13 illustrates four collision types U1 to U4 ref. to the research work of Institute of Vehicle Safety, a Dept. of German Insurers Association and a highway column.

Fig. 14 is a perspective view of interlocking assemblies of the 3rd embodiment comprising a stiff front door frame having a single window-guide element and a stiff rear door frame having a single window-guide element to engage with the post sections and peripheral edges of vehicle body.

Fig. 15 is a cross-sectional view of the series-connected doors in engagement with the A-, B-post section and of the vehicle body along the line D-D in **Fig.** 14.

Fig. 16 is a side view of the series-connected stiff door frames without window pane in engagement with the B-post section according to arrow E in **Fig.** 14.

Fig. 17 is a perspective view of interlocking assemblies of the 4th embodiment comprising a stiff front door frame having a single window-guide element in engagement with the peripheral edges of vehicle body.

Fig. 18 is a side view of the peripheral edges of vehicle body provided with interlocking blocks.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Fig. 3 the 1st embodiment consists of interlocking assemblies, whose interlocking parts are attached to two window-guide elements of vehicle door and whose interlocking mating parts to the A- and B-post section, vehicle roof and side rail.

In Fig. 4 the 2nd embodiment consists of an interlocking assembly, whose interlocking hooks are attached to two window-guide elements of each vehicle door and whose reinforcing rod to the vehicle roof and all post sections. The reinforcing rod serves to reinforce the vehicle roof and to aid positioning at the assembly thus cutting costs. However, this embodiment needs space, which is available in large cars, trucks and vans. This embodiment is suited for another compound assembly: vehicle door/s & side rail.

In Figs. 14 to 16 the 3rd embodiment consists of interlocking assemblies, whose interlocking parts are attached to a window-guide element of each vehicle door **8, 8B** and whose interlocking mating parts to the A-, B-post section and respective reinforcing elements **21.3, 21.3B** of peripheral edges **21** of vehicle body **20**. The interlocking blocks **30** to **37** & interlocking holes can arbitrarily be attached to vehicle doors, post sections and vehicle body. After welding the reinforcing element **23** to the inner region of B-post section the interlocking holes are machined.

The 4th embodiment consists of

- interlocking assembly **30 & 6.5, 35 & 6.5B** and other interlocking assembly **32 & 6.9, 37 & 6.9B (6.9, 6.9B** similar to **6.5)** in **Fig. 17**,
- peripheral edges **21** of vehicle body **20** and the enlarged peripheral edges defined by the dotted lines "a1", "b1", "b2" and "c1" along the post sections to house the interlocking blocks **30, 32, 35, 37** in **Fig. 18**,
- two compound assemblies such as peripheral edge **21** of vehicle body **20** & window-guide element **6** of front door **8** and peripheral edge of vehicle body **20** & window-guide element **6B** of rear door **8B** and.
- interlocking blocks **30, 32, 35, 37** rigidly attached to the respective reinforcing elements **21.1 to 21.5, 21.1B to 21.5B** of peripheral edges **21** of vehicle body **20**. The welding of reinforcing elements to the peripheral edges facing to the vehicle doors has the advantage of using only a single element such as **21.4, 21.1B**. Those elements can be arranged between both panels of vehicle body. The reinforcing element **21.5B** is welded to the peripheral edge and rear wheel case. The same reinforcing method can be employed to arrange a similar element **21.1** to the peripheral edge and the front wheel case.

According to the description of DE 4342038 A1 a stiff door frame of vehicle door can be assembled, without door girder and reinforcing elements, from at least two impact beams provided with interlocking assemblies and at least one window-guide element **6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB**. As is customary, the window-guides **6.1, 6.2, 6.1B, 6.2B** in **Figs. 1** and **3** are made from U-shaped thin panel. As *reinforcing elements* the window-guide elements are of higher-grade tensile strength **6.1a, 6.2a, 6.1aB, 6.2aB** to:

- reinforce the U-shaped window-guides of metal sheets,
- receive interlocking parts such as interlocking hooks, interlocking blocks and/or interlocking holes and
- receive auxiliary parts **6.5, 6.5B, 6.6a, 6,6b, 6.7a, 6.7b, 6.8, 6.9** (not drawn) as structural element with higher-grade tensile strength.

The following auxiliary parts are fixedly attached
- **6.8, 6.9** to the front faces of both impact beams **1B, 7B** and window-guide element **6B**,
- **6.6b, 6.7b** to window-guide element **6** and impact beams **7** and
- **6.6a, 6.7a** between both impact beams **1, 7** and window-guide element **6**.

Both window-guide elements are replaceable by an U-shaped stiff window-guide element **6, 6B** in **Figs.** 2, 2A, 14 to 17. Less stiff elements **6.3, 6.3B** are normally made of panel. Alternately, very stiff window-guide element **6.3, 6.3B** serves to receive the window pane and interlocking blocks **15.7**.

Window-guide element **6, 6B** provided with window-guide element **6.3, 6.3B** in the door cavity in **Fig.** 2A have open ends. To maximize the stiffness of window-guide element **6, 6B** both ends are rigidly connected with each other by window-guide element **6.4, 6.4B** in the door cavity in **Figs.** 2, 14 to 17:
- after the window pane has been inserted, *or*
- by having flat profile in **Figs.** 14, 15, 17 for the purpose of receiving window pane **60, 60B** in **Fig.** 15. Later on, this window pane must be secured against falling down by protective parts.

The window-guide element **6.4, 6.4B** is useful for accommodation of interlocking parts **15.8**. If extraneous weight is not that important for heavy cars, trucks and vans, the following goals for independent parts are applicable:
- the window-guide element fastened to the impact beams serving as members of door frame to receive interlocking parts and
- the window-guides of panel to guide and receive the window pane.

To engage with the interlocking mating parts the following interlocking parts are attached:
- **15.1, 15.2, 15.2a, 15.3, 15.3a, 15.4, 15.4a, 15.5** and **15.5a** along the vehicle roof, side rail and post sections,
- **15.3, 15.3a** and/or **15.5, 15.5a** to the *mutual* post section of the juxtaposed vehicle doors e.g. *B- and C- post section* of 6-door vans,
- **30** and **31** to the A-post section,
- **33, 34, 35 and 36** to the *mutual* post section of the juxtaposed vehicle doors,
- **33** and **34** to the C-post section,
- **15.7** replaced by at least one interlocking block **15.2, 15.2a, 15.4, 15.4a, 30 to 37** along the vehicle roof,
- **15.8** replaced by at least one interlocking block **15.2, 15.2a, 15.4, 15.4a, 30 to 37** along the side rail.

By means of this design interlocking blocks **15.1** can generally be attached to the post section having door hinges.

In the following embodiments in **Figs.** 3, 4, 14 to 18 the connection of all series-connected doors with vehicle roof **17**, vehicle body **20**, vehicle floor fastened to two side rails **18** facing each other and with the respective post sections in any collision and/or rollover is ensured by engagement of the following interlocking blocks **15.1 to 15.5a, 30 to 37** with interlocking holes and/or of the following interlocking hooks **15.6** with reinforcing rod **17.1d**:
- interlocking block **15.1**, bolted to a reinforcing element of the L-shaped A-post section, with the interlocking oblong hole of window-guide element **6.1a**. This A-post section is welded to reinforcing panel **17.1c** disposed along the vehicle roof and to transverse girder **17.2d** of both facing A-post sections of both vehicle sides. This feature is applicable for window-guide element **6.2a, 6.1aB, 6.2aB** in association with the B- or C-post section.

- interlocking block **15.2a**, bolted to block **6.11** of window-guide element **6.1a**, with the interlocking oblong hole of reinforcing panel **17.1** disposed along the vehicle roof. This panel is welded to reinforcing plate **17.2a** of the L-shaped A-post section and to transverse girders **17.2, 17.2b** of both facing A-post sections. To cut costs the reinforcing plate **17.2a** can act as transverse girder by eliminating parts **17.2, 17.2b**. These features are applicable for window-guide element **6.2a, 6.1aB, 6.2aB** in association with the B- or C-post section.
- interlocking block **15.2**, bolted to window-guide element **6.2a**, with the interlocking hole of reinforcing panel **17.1a** disposed along the vehicle roof. This feature is applicable for engagement of interlocking block **15.2** bolted to window-guide element **6.1a, 6.1aB, 6.2aB** with the interlocking hole.
- interlocking block **15.3** and interlocking block **15.3a**, bolted to the legs of U-shaped block **17.3**, with the interlocking apertures of window-guide elements **6.2a, 6.1aB**. As connection element between the B-post section and the vehicle roof this U-shaped block in the B-post section is welded to reinforcing panel **17.1b** disposed along the vehicle roof and to transverse girder **17.2c** of both facing B-post sections of both vehicle sides.
- interlocking block **15.4**, bolted to the reinforcing plate of reinforcing panel **18.1** disposed along the side rail, with the interlocking hole of window-guide element **6.1a**. This feature is applicable for window-guide elements **6.2a, 6.1aB, 6.2aB**.
- interlocking block **15.4a** such as pin e.g. ref. to DIN660, fastened to the reinforcing plate of reinforcing panel **18.1a** disposed along the side rail, with the interlocking hole of window-guide element **6.2a**.
- interlocking block **15.2a** in x-y operating plane as substitute for interlocking block **15.4, 15.4a** or **15.8**.
- interlocking block **15.5** and interlocking block **15.5a**, bolted to the legs of U-shaped block **18.3**, with the interlocking apertures of window-guide elements **6.2a, 6.1aB**. As connection element between the B-post section and the vehicle floor this U-shaped block in the B-post section is welded to reinforcing panel **18.1b** disposed along the vehicle floor and to transverse girder **18.2** of both facing B-post sections of both vehicle sides. The belt case **26** can be housed in U-shaped block **18.3**.
- interlocking hooks **15.6**, bolted to window-guide elements **6.1a, 6.2a, 6.1aB, 6.2aB**, with the reinforcing rod **17.1d** disposed along the vehicle roof or side rail in **Fig.** 4. This rod is welded to transverse girders **17.2e, 17.2f, 17.2g** of both A-, B- and C-post sections.
- interlocking blocks **30, 32, 35, 37**, bolted to the respective reinforcing elements **21.3, 21.5, 21.3B, 21.5B** of the bottom peripheral edges of vehicle body **20** in **Figs.** 14 to 18, with the corresponding interlocking holes of auxiliary parts **6.5, 6.5B** which are rigidly attached to the respective window-guide elements **6, 6B** and the respective auxiliary parts **6.6b, 6.7b, 6.8, 6.9** (not drawn because of the similarity to **6.7b**).
- interlocking blocks **30, 32, 35, 37**, bolted to the respective reinforcing elements **21.1, 21.4, 21.1B, 21.4B** of the top peripheral edges **21** of vehicle body **20**, with the corresponding interlocking holes of auxiliary parts **6.5, 6.5B** which are rigidly attached to the respective window-guide elements **6, 6B**.
- interlocking blocks **30, 35**, bolted to the respective reinforcing elements **21.2, 21.2B**, which at halfway up location are fixed to the post-section-peripheral edges **21** of vehicle body **20**, with the corresponding interlocking holes of auxiliary parts **6.5, 6.5B** which are rigidly attached to the respective window-guide elements **6, 6B** and the respective impact beams **1, 1B**.

- interlocking blocks **31**, bolted to auxiliary part **6.6a** of window-guide element **6**, with the interlocking holes of (machined in) the reinforced A-post section in **Figs.** 14 to 16.
- interlocking blocks **36**, bolted to auxiliary part **6.8** of window-guide element **6B**, with the respective interlocking holes of the B-post section reinforced by reinforcing element **23**.
- interlocking blocks **33**, bolted to window-guide element **6**, with the respective interlocking holes in the reinforced B-post section. Similarly, the interlocking blocks **33** can be attached to window-guide element **6B** and the respective interlocking holes of the reinforced C-post section. In **Fig.** 16 a washer **15.13** with radial teeth serves as part of interlocking block **33** to improve the engagement with the inner region of the reinforced B-post section in any collision and/or rollover. As an integral part of a screw ref. to DIN 931 Form Z the washer won't become loose on assembly.
- interlocking blocks **34**, bolted to auxiliary part **6.7a** of window-guide element **6**, with the respective interlocking holes of the reinforced B-post section. Similarly, the interlocking blocks **3e** can be attached to auxiliary part **6.9** of window-guide element **6B** and the respective interlocking holes of the reinforced C-post section.

It is possible to arrange

- several pairs of interlocking blocks **15.3, 15.5** to the legs of U-shaped block **17.3, 18.3** and
- several interlocking blocks **30, 32, 35, 37** with the same feature in the enlarged peripheral edges **21** of vehicle body **20** defined by the dotted lines "a1", "b1", "b2" and "c1" in **Fig.** 18.

By applying the associative rule for the arrangement of each interlocking assembly the attachment of interlocking block and hole to the corresponding parts is reversible.

By welding a reinforcing plate to the surface of the site of interlocking part a structural reinforcement is achieved. If extraneous weight is insignificant for heavy vehicle like truck or van, replace reinforcing panel by beam or beam-rod.

Costs can be cut by using mechanical connecting parts, particularly standard parts like washer ref. to DIN125, hexagon socket head screw ref. to DIN912 etc. This is exemplified by interlocking block **15.4a** as rivet ref. to DIN660. With the exception of **15.4a** each interlocking block **15.1 to 15.5a, 30 to 37** comprises a screw **15.14**, a sleeve **15.11**, a number of washers built into one spacer **15.12** and a washer with a large exterior diameter **15.13** illustrated in **Figs.** 3A, 14 to 18.

Despite larger tolerances the most inexpensive interlocking block **15.4a** in association with the other interlocking blocks **15.1 to 15.5a** is suited for engagement with the respective interlocking holes. However, for perfect inter-engagement at low cost by limited use of the interlocking assembly, the provision with interlocking blocks **15.1 to 15.8, 30 to 37** without interlocking block **15.4a** is ultimately necessary.

In order to ensure the engagement of interlocking block with interlocking mating hole a clearance in **Figs.** 3A, 14 to 18 must be preserved by:

- correcting the length of spacer l by removing or adding several washers and/or
- assembling a sleeve with exterior diameter d, washer with exterior diameter D and/or spacer with diameter d_R chosen from the stock of the sleeves, washers and/or spacers with different diameters.

Each interlocking hook **15.6** in **Figs.** 4 and 4A comprises a hook **15.20** with interior diameter d_1 and gap s_1 smaller than d_1, a screw **15.21**, a number of washers built into one spacer **15.22**, a coil-spring washer **15.24** and a nut **15.25.** The symbols s_1, d_1 and d_2 are indicated in **Fig.** 4A. In order to ensure perfect engagement of the interlocking hooks with

reinforcing rod **17.1d** having diameter d_2 smaller than s_1, small tolerance zones in **Fig. 4A** must be preserved by:

- assembling a hook with gap s_1 chosen from the stock of the hooks with different gaps;
- assembling a rod with diameter d_2 chosen from the stock of the reinforcing rods with different diameters;
- correcting the distance l_1 by removing or adding several washers of spacer; and/or
- positioning the centres of the hook hole and the reinforcing rod out of alignment.

Although the present invention has been described and illustrated in detail, it is clearly understood that the terminology used is intended to describe rather than limit. Many more objects, embodiments, features and variations of the present invention are possible in light of the above-mentioned teachings. Therefore, within the spirit and scope of the appended claims, the present invention may be practised otherwise than as specifically described and illustrated.

What is claimed:

1. An increased stiffness of vehicle structure comprising

a) a main vehicle body **(20)** having at least one door aperture **(20.1, 20.1B, 20.1T, 20.1x)** therein;

b) a mating vehicle door **(8, 8B, 8T, 8x)**, generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate door, trunk cover **(8x)** and vehicle door **(8, 8B)**, whose stiff supporting door frame, defined by at least two stiff impact beams **(1, 7, 1B, 7B)**, stiff auxiliary parts and at least one stiff window-guide element **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

c) interlocking assemblies, each of which including an interlocking part arranged to that door frame and an interlocking mating part to the vehicle body **(20)**;

d) adjusting mechanisms to adjust to clearances of adjustable interlocking assemblies, which are in engagement when the vehicle door is in a closed position;

thus ensuring the engagement of all compound assemblies of vehicle structure such as vehicle door & vehicle roof **(17)**, vehicle door & side rail **(18)**, vehicle door & post sections and vehicle door & peripheral edge **(21, 21T, 21h, 21x)** of vehicle body **(20)**, distributing impact energy to all those vehicle parts, lowering stress thereof and preventing passengers from being hurled out of the vehicle in the event of any real collision and/or rollover.

2. An increased stiffness of vehicle structure according to claim **1**, wherein the vehicle part of vehicle body **(20)** receiving the interlocking parts is reinforced by a reinforcing element and transverse girder of the post sections of both vehicle sides.

3. An increased stiffness of vehicle structure according to claim **2**, wherein the interlocking assembly of vehicle door & vehicle part **(17, 18)**, which is vehicle roof or side rail, is defined by

- a reinforcing rod **(17.1d)** disposed along that vehicle part and fixed to two transverse girders **(17.2e, 17.2f** or **17.2f, 17.2g)**; and
- at least two interlocking mating hooks **(15.6)** fixed to the window-guide elements **(6.1a, 6.2a, 6.3, 6.4** or **6.1aB, 6.2aB, 6.3B, 6.4B)**.

4. An increased stiffness of vehicle structure according to claim 3, wherein the interlocking assembly of juxtaposed vehicle doors & vehicle part (17, 18), which is vehicle roof or side rail, is defined by
- the reinforcing rod (17.1d) disposed along that vehicle part and fixed to the transverse girders (17.2e, 17.2f, 17.2g); and
- at least four interlocking mating hooks (15.6) fixed to the corresponding window-guide elements (6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B).

5. An increased stiffness of vehicle structure according to claim 4, wherein two interlocking assemblies of juxtaposed vehicle doors & vehicle roof (17) and juxtaposed vehicle doors & side rail (18) are defined by
- two reinforcing rods (17.1d) disposed along that reinforcing vehicle roof and that reinforcing side rail; and
- at least eight interlocking mating hooks (15.6) fixed to the corresponding window-guide elements.

6. An increased stiffness of vehicle structure according to claim 2, wherein the adjustable interlocking assemblies are defined by
- disposing the interlocking holes to both window-guide elements of both vehicle doors (8, 8B) in juxtaposition and
- bolting at least one pair of interlocking mating blocks (15.3, 15.3a) to both legs of U-shaped block (17.3) rigidly attached to the mutual post section of those vehicle doors, a reinforcing panel (17.1b) disposed along the vehicle roof (17) and a transverse girder (17.2c) of the mutual post sections of both vehicle sides.

7. An increased stiffness of vehicle structure according to claim 2, wherein the adjustable interlocking assemblies are defined by
- disposing the interlocking holes to both window-guide elements of both vehicle doors (8, 8B) in juxtaposition and
- bolting at least one pair of interlocking blocks (15.5, 15.5a) to both legs of U-shaped block (18.3) rigidly attached to the mutual post section of those vehicle doors, a reinforcing panel (18.1b) disposed along the side rail (18) and a transverse girder (18.2) of the mutual post sections of both vehicle sides.

8. An increased stiffness of vehicle structure according to claim 7, wherein a belt case (26) is housed in the U-shaped block (18.3).

9. An increased stiffness of vehicle structure according to claim 2, wherein the adjustable interlocking assemblies, interlocking holes & interlocking blocks (15.1, 31, 36) of vehicle door (8, 8B) & post section, operating in two planes are defined by disposing
- the interlocking parts to the reinforcing post section, whereto the door frame is hingedly secured, and
- the interlocking mating parts to the reinforcing window-guide element of that door frame adjacent to that post section.

10. An increased stiffness of vehicle structure according to claim 9, wherein the adjustable interlocking assembly includes

- the interlocking hole disposed in the window-guide element **(6.1a, 6.2a, 6.1aB, 6.2aB)** and
- the interlocking mating block **(15.1)** rigidly attached to a reinforcing plate of the post section, whereto the transverse girder **(17.2d)** and reinforcing panel **(17.1c)**, disposed along the vehicle roof or side rail, are rigidly attached.

11. An increased stiffness of vehicle structure according to claim 2, wherein the adjustable interlocking assembly include

- an interlocking block **(15.2a)** rigidly attached to a block **(6.11)** of window-guide element **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)** and
- an interlocking mating hole arranged in a reinforcing panel **(17.1)** disposed along the vehicle roof **(17)** or side rail **(18)**, where that reinforcing panel **(17.1)** is rigidly attached to the post section and
  - to a reinforcing plate **(17.2a)** and transverse girders **(17.2, 17.2b)** *or*
  - to a reinforcing plate **(17.2a)**.

12. An increased stiffness of vehicle structure according to claim 2, wherein the interlocking assemblies include

- the interlocking holes arranged in the reinforcing panels **(17.1a, 18.1, 18.1a)** disposed along the vehicle **(17)** or side rail **(18)** and
- the interlocking mating blocks **(15.2, 15.4, 15.4a)** fixed to the respective window-guide elements **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)**.

13. An increased stiffness of vehicle structure according to claim 12, wherein the interlocking assemblies include

- the interlocking holes arranged in the reinforcing panels **(17.1a, 18.1, 18.1a)** disposed along the vehicle **(17)** and side rail **(18)**, respectively, and
- the interlocking mating blocks **(15.2, 15.4, 15.4a)** fixed to the respective window-guide elements.

14. An increased stiffness of vehicle structure according to claim 2, wherein the adjustable interlocking assemblies are defined by

- bolting the interlocking blocks **(30, 32, 35, 37)** to the reinforcing peripheral edges **(21)** of vehicle body **(20)** and
- disposing the interlocking mating holes to the window-guide element.

15. An increased stiffness of vehicle structure according to claim 14, wherein the adjustable interlocking assembly includes

- the interlocking block **(30, 32, 35)** fixed to a reinforcing element **(21.1, 21.4, 21.1B)** of the top peripheral edge **(21)** of vehicle body **(20)** and
- the interlocking mating hole disposed in an auxiliary part **(6.5, 6.5B)** fixed to the window-guide element **(6, 6B)**.

16. An increased stiffness of vehicle structure according to claim 14, wherein the adjustable interlocking assembly includes

- the interlocking block **(30, 32, 35)** fixed to a reinforcing element **(21.3, 21.5, 21.3B)** of the bottom peripheral edge **(21)** of vehicle body **(20)** and
- the interlocking mating hole arranged in the auxiliary part **(6.5, 6.5B)** fixed to the window-guide element **(6, 6B)** and an auxiliary part **(6.6b, 6.7b, 6.8)**.

17. An increased stiffness of vehicle structure according to claim **14**, wherein the adjustable interlocking assembly includes

- the interlocking block **(30, 35)** fixed to a reinforcing element **(21.2, 21.2B)** of the post-section-peripheral edge **(21)** of vehicle body **(20)** and
- the interlocking mating hole arranged in the auxiliary part **(6.5, 6.5B)** fixed to the window-guide element **(6, 6B)** and impact beam **(1, 1B)**.

18. An increased stiffness of vehicle structure according to claim **14**, wherein an auxiliary part **(6.5C)**, adapted to the outer door-contour, is rigidly arranged to the window-guide element **(6B)** and impact beams **(1B, 7B)**.

19. An increased stiffness of vehicle structure according to claim **18**, wherein the adjustable interlocking assembly includes

- the interlocking block **(37)** rigidly attached to a reinforcing element **(21.4B, 21.6B, 21.5B)** of the post-section-peripheral edge **(21)** of vehicle body **(20)** and
- the interlocking mating hole arranged in the outer door-contour-shaped auxiliary part **(6.5C)**.

20. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assembly includes

- an interlocking block **(31, 36)** rigidly attached to an auxiliary part **(6.6a, 6.8)** of window-guide element **(6, 6B)** and
- an interlocking mating hole arranged in the post section reinforced by a reinforcing element **(23)** and adjacent to that window-guide element.

21. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assemblies of vehicle door **(8)** & post section operating in two planes are defined by

- bolting the interlocking blocks **(33, 34)** to a post section, reinforced by the reinforcing element **(23)**, having a striker **(298)** of latch mechanism **(248)** and
- disposing the interlocking mating holes to the window-guide element of vehicle door adjacent to that post section.

22. An increased stiffness of vehicle structure according to claim **21**, wherein the adjustable interlocking assembly includes

- the interlocking block **(33)** rigidly attached to the window-guide element **(6, 6B)** and
- the interlocking mating hole arranged in the post section, reinforced by the reinforcing element **23)**, having the striker **(298)** of latch mechanism **(248)** and adjacent to that window-guide element.

23. An increased stiffness of vehicle structure according to claim **21**, wherein the adjustable interlocking assembly includes

- the interlocking block **(34)** rigidly attached to an auxiliary part **(6.7a)** of the window-guide element **(6, 6B)** and
- the interlocking mating hole arranged in the post section, reinforced by the reinforcing element **(23)**, having the striker **(298)** of latch mechanism **(248)** and adjacent to that window-guide element.

24. An increased stiffness of vehicle structure according to claim **1**, wherein both ends of the stiff U-shaped window-guide element **(6, 6B)**, facing the lower vehicle part of vehicle body **(20)**, and an upper part of that window-guide element, facing the upper vehicle part of vehicle body **(20)**, receive the interlocking parts.

25. An increased stiffness of vehicle structure according to claim **24**, wherein the window-guide element **(6.4, 6.4B)** is rigidly attached to the respective stiff U-shaped window-guide elements **(6, 6B)**.

26. An increased stiffness of vehicle structure according to claim **1**, wherein the window-guides **(6.1, 6.2, 6.1B, 6.2B)** are rigidly attached to the respective stiff window-guide elements **(6.1a, 6.2a, 6.1aB, 6.2aB)**.

27. An increased stiffness of vehicle structure according to claim **1**, wherein two window-guides are rigidly attached to the stiff window-guide element **(6, 6B)**.

28. An increased stiffness of vehicle structure according to claim **1**, wherein the interlocking part comprising mechanical connection elements such as screw, rivet, washer, nut, pin, interlocking rings etc. and
- the interlocking hook **(15.6)** with interior diameter d_1 and gap s_1 or
- a sleeve **(15.11)** and washer **(15.13)** with outer diameter D in case of interlocking block,

is provided with a means to adjust the clearances between the mating interlocking parts from outside the vehicle.

29. An increased stiffness of vehicle structure according to claim **28**, wherein the front region of washer **(15.13)** has radial teeth.

30. An increased stiffness of vehicle structure according to claim **29**, wherein the washer is an integral part of a screw.

31. An increased stiffness of vehicle structure according to claim **28**, wherein the washer is an integral part of a screw.

32. An increased stiffness of vehicle structure according to claim **1**, wherein the sleeve **(15.11)** of interlocking part with exterior diameter d is governed by the equation $D \geq d \geq d_R$, where D is the exterior diameter of washer **(15.13)** and d_R is the diameter of spacer **(15.12)**.

33. An increased stiffness of vehicle structure comprising

a) a main vehicle body **(20)** having at least one door aperture **(20.1, 20.1B, 20.1T, 20.1x)** therein;

b) a mating vehicle door **(8, 8B, 8T, 8x)**, generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate- and vehicle door **(8, 8B)**, whose stiff supporting door frame, defined by at least two stiff impact beams **(1, 7, 1B, 7B)**, stiff auxiliary parts and at least one stiff window-guide element **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

c) interlocking assemblies, each of which including an interlocking part arranged to that door frame and an interlocking mating part to the vehicle body **(20)**;

d) adjusting mechanisms to adjust to clearances of adjustable interlocking assemblies, which are in engagement when the vehicle door is in a closed position;

e) wherein the interlocking assemblies of compound assembly of vehicle structure such as vehicle door & vehicle roof **(17)**, vehicle door & side rail **(18)**, vehicle door & post sections and/or vehicle door & peripheral edge **(21, 21T, 21h, 21x)** of vehicle body **(20)** operate in at least two planes in reference to the xyz global coordinate system of vehicle;

thus substantially ensuring the engagement of all compound assemblies, distributing impact energy to all vehicle parts of vehicle structure, lowering stress thereof and preventing passengers from being hurled out of the vehicle in the event of any real collision and/or rollover.

34. An increased stiffness of vehicle structure according to claim **33**, characterised by use of metal, compound material, glass fibre reinforced material or non-metal material for material of the interlocking part, window-guide element, auxiliary part, reinforcing element, transverse girder, reinforcing rod, plate, panel and U-shaped block.

ABSTRACT

In order to ensure engagement of all compound assemblies, when vehicle door/s is/are in closed position, such as

vehicle door **(8)** & vehicle door **(8B)**, vehicle door & vehicle roof **(17)**, vehicle door & side rail **(18)**, vehicle door & post section/s and vehicle door & peripheral edge **(21, 21T, 21h, 21x)**,

to distribute great energy thereto, substantially lower stress thereof and definitely resolve the failure of passenger protection in real accidents, disclosed therein and in [1, 4 to 14],

1. an adjusting mechanism, to adjust large tolerances to proper clearances, is provided for an interlocking assembly, both mating parts of which are disposed to a stiff door frame of the vehicle door **(8, 8B, 8T, 8x, 8h)** and the mating part of vehicle structure; and/or
2. all interlocking assemblies of the compound assembly operate in at least two planes.

This inventive technology is suitable for other types of vehicle door such as tailgate door, sliding side door, liftgate door, cargo door, trunk cover and hood, where all vehicle doors, when closed, and the vehicle body are formed into a compound construction being capable of sustaining great impact energy.

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[2] Problematik der Auslegung von Schraubendruckfedern unter Berücksichtigung des Abwälzverhaltens (Go, Automobil-Industrie 3/82, pp 359-367)

[3] Zum Schwingungsverhalten von Schraubendruckfedern (Go, ATZ 84 (1982), pp 223-226)

[4] World-wide safest, expensive German sport car in rollover ref. to accident report of Wiesbadener Kurier of July 27, 1998 and Go's report

[5] Brand-new luxury German car in side collision and rollover ref. to accident police report of Nov. 27, 1994 and Go's report

[6] Luxury German car in front collision ref. to Wiesbadener Tagblatt of Aug. 1, 1996 and accident police report of July 31, 1996

[7] Brand-new luxury German car in side collision and rollover ref. to Wiesbadener Tagblatt of Nov. 21, 1997

[8] Small German car in side collision ref. to Wiesbadener Tagblatt of Oct. 7, 1996

[9] Unknown car in side collision and rollover ref. to Wiesbadener Tagblatt of Oct. 1 1996

[10] Convertible German car in rollover ref. to Wiesbadener Tagblatt of Nov. 09, 1998

[11] Luxury German car in side collision ref. to Wiesbadener Tagblatt of Dec. 3, 1994

[12] Top luxury German car in rollover ref. to accident police report of Feb. 02, 1997 and Go's report

[13] German car of an American car manufacturer, having sufficient test results in crash tests, in rear collision and rollover ref. to accident police report of Feb. 2, 1995 and Go's report

[14] Italian compact car in front collision ref. to Wiesbadener Tagblatt of Sept. 30, 1997

[15] Research work "Vehicle Safety in 1990s" ("Fahrzeugsicherheit 90") by Institute of Vehicle Safety (German NHSTA), a Dept. of German Insurers Association, in Munich

[16] Auto Motor and Sport issue 12/1997 pp. 28 "gleichmäßige enge Spaltmaße"

[17] Auto Motor and Sport issue 18/1996 pp. 28 "Neue Qualität in der Optik: 3.5 mm breite Spalte" stated by VW CEO Dr. -Ing. Ferdinand Piëch.

[18] ADAC issue 9/1995

[19] NHSTA's letter of a director of Nov. 24, 98

[4] Porsche 911
[5] VW VR6
[6] BMW 5
[7] BMW 5
[8] Opel Corsa
[9] Unknown car
[10] Convertible car BMW 3
[11] MB 190
[12] MB E320
[13] Ford Escort
[14] Fiat Tipo

1. An increased stiffness of vehicle structure comprising

a) a main vehicle body **(20)** having at least one door aperture **(20.1, 20.1B, 20.1T, 20.1x)** therein;

b) a mating vehicle door **(8, 8B, 8T, 8x)**, generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate door, trunk cover **(8x)** and vehicle door **(8, 8B)**, whose stiff supporting door frame, defined by at least two stiff impact beams **(1, 7, 1B, 7B)**, stiff auxiliary parts and at least one stiff window-guide element **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

c) interlocking assemblies, each of which including an interlocking part arranged to that door frame and an interlocking mating part to the vehicle body **(20)**;

d) adjusting mechanisms to adjust to clearances of adjustable interlocking assemblies, which are in engagement when the vehicle door is in a closed position;

thus ensuring the engagement of all compound assemblies of vehicle structure such as vehicle door & vehicle roof **(17)**, vehicle door & side rail **(18)**, vehicle door & post sections and vehicle door & peripheral edge **(21, 21T, 21x)** of vehicle body **(20)**, distributing impact energy to all those vehicle parts, lowering stress thereof and preventing passengers from being hurled out of the vehicle in the event of any real collision and/or rollover.

2. An increased stiffness of vehicle structure according to claim **1**, wherein the vehicle part of vehicle body **(20)** receiving the interlocking parts is reinforced by a reinforcing element and transverse girder of the post sections of both vehicle sides.

3. An increased stiffness of vehicle structure according to claim **2**, wherein the interlocking assembly of vehicle door & vehicle part **(17, 18)**, which is vehicle roof or side rail, is defined by

- a reinforcing rod **(17.1d)** disposed along that vehicle part and fixed to two transverse girders **(17.2e, 17.2f** or **17.2f, 17.2g)**; and
- at least two interlocking mating hooks **(15.6)** fixed to the window-guide elements **(6.1a, 6.2a, 6.3, 6.4** or **6.1aB, 6.2aB, 6.3B, 6.4B)**.

4. An increased stiffness of vehicle structure according to claim **3**, wherein the interlocking assembly of juxtaposed vehicle doors & vehicle part **(17, 18)**, which is vehicle roof or side rail, is defined by

- the reinforcing rod **(17.1d)** disposed along that vehicle part and fixed to the transverse girders **(17.2e, 17.2f, 17.2g)**; and
- at least four interlocking mating hooks **(15.6)** fixed to the corresponding window-guide elements **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)**.

5. An increased stiffness of vehicle structure according to claim **4**, wherein two interlocking assemblies of juxtaposed vehicle doors & vehicle roof **(17)** and juxtaposed vehicle doors & side rail **(18)** are defined by

- two reinforcing rods **(17.1d)** disposed along that reinforcing vehicle roof and that reinforcing side rail; and
- at least eight interlocking mating hooks **(15.6)** fixed to the corresponding window-guide elements.

6. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assemblies are defined by

- disposing the interlocking holes to both window-guide elements of both vehicle doors **(8, 8B)** in juxtaposition and
- bolting at least one pair of interlocking mating blocks **(15.3, 15.3a)** to both legs of U-shaped block **(17.3)** rigidly attached to the mutual post section of those vehicle doors, a reinforcing panel **(17.1b)** disposed along the vehicle roof **(17)** and a transverse girder **(17.2c)** of the mutual post sections of both vehicle sides.

7. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assemblies are defined by

- disposing the interlocking holes to both window-guide elements of both vehicle doors **(8, 8B)** in juxtaposition and

- bolting at least one pair of interlocking blocks **(15.5, 15.5a)** to both legs of U-shaped block **(18.3)** rigidly attached to the mutual post section of those vehicle doors, a reinforcing panel **(18.1b)** disposed along the side rail **(18)** and a transverse girder **(18.2)** of the mutual post sections of both vehicle sides.

8. An increased stiffness of vehicle structure according to claim **7**, wherein a belt case **(26)** is housed in the U-shaped block **(18.3)**.

9. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assemblies, interlocking holes & interlocking blocks **(15.1, 31, 36)** of vehicle door **(8, 8B)** & post section, operating in two planes are defined by disposing

- the interlocking parts to the reinforcing post section, whereto the door frame is hingedly secured, and
- the interlocking mating parts to the reinforcing window-guide element of that door frame adjacent to that post section.

10. An increased stiffness of vehicle structure according to claim **9**, wherein the adjustable interlocking assembly includes

- the interlocking hole disposed in the window-guide element **(6.1a, 6.2a, 6.1aB, 6.2aB)** and
- the interlocking mating block **(15.1)** rigidly attached to a reinforcing plate of the post section, whereto the transverse girder **(17.2d)** and reinforcing panel **(17.1c)**, disposed along the vehicle roof or side rail, are rigidly attached.

11. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assembly include

- an interlocking block **(15.2a)** rigidly attached to a block **(6.11)** of window-guide element **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)** and
- an interlocking mating hole arranged in a reinforcing panel **(17.1)** disposed along the vehicle roof **(17)** or side rail **(18)**, where that reinforcing panel **(17.1)** is rigidly attached to the post section and
  - * to a reinforcing plate **(17.2a)** and transverse girders **(17.2, 17.2b)** *or*

* to a reinforcing plate **(17.2a)**.

12. An increased stiffness of vehicle structure according to claim **2**, wherein the interlocking assemblies include

- the interlocking holes arranged in the reinforcing panels **(17.1a, 18.1, 18.1a)** disposed along the vehicle **(17)** or side rail **(18)** and
- the interlocking mating blocks **(15.2, 15.4, 15.4a)** fixed to the respective window-guide elements **(6.1a, 6.2a, 6.3, 6.4, 6.1aB, 6.2aB, 6.3B, 6.4B)**.

13. An increased stiffness of vehicle structure according to claim **12**, wherein the interlocking assemblies include

- the interlocking holes arranged in the reinforcing panels **(17.1a, 18.1, 18.1a)** disposed along the vehicle **(17)** and side rail **(18)**, respectively, and
- the interlocking mating blocks **(15.2, 15.4, 15.4a)** fixed to the respective window-guide elements.

14. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assemblies are defined by

- bolting the interlocking blocks **(30, 32, 35, 37)** to the reinforcing peripheral edges **(21)** of vehicle body **(20)** and
- disposing the interlocking mating holes to the window-guide element.

15. An increased stiffness of vehicle structure according to claim **14**, wherein the adjustable interlocking assembly includes

- the interlocking block **(30, 32, 35)** fixed to a reinforcing element **(21.1, 21.4, 21.1B)** of the top peripheral edge **(21)** of vehicle body **(20)** and
- the interlocking mating hole disposed in an auxiliary part **(6.5, 6.5B)** fixed to the window-guide element **(6, 6B)**.

16. An increased stiffness of vehicle structure according to claim **14**, wherein the adjustable interlocking assembly includes

- the interlocking block **(30, 32, 35)** fixed to a reinforcing element **(21.3, 21.5, 21.3B)** of the bottom peripheral edge **(21)** of vehicle body **(20)** and
- the interlocking mating hole arranged in the auxiliary part **(6.5, 6.5B)** fixed to the window-guide element **(6, 6B)** and an auxiliary part **(6.6b, 6.7b, 6.8)**.

17. An increased stiffness of vehicle structure according to claim **14**, wherein the adjustable interlocking assembly includes

- the interlocking block **(30, 35)** fixed to a reinforcing element **(21.2, 21.2B)** of the post-section-peripheral edge **(21)** of vehicle body **(20)** and
- the interlocking mating hole arranged in the auxiliary part **(6.5, 6.5B)** fixed to the window-guide element **(6, 6B)** and impact beam **(1, 1B)**.

18. An increased stiffness of vehicle structure according to claim **14**, wherein an auxiliary part **(6.5C)**, adapted to the outer door-contour, is rigidly attached to the window-guide element **(6B)** and impact beams **(1B, 7B)**.

19. An increased stiffness of vehicle structure according to claim **18**, wherein the adjustable interlocking assembly includes

- the interlocking block **(37)** rigidly attached to a reinforcing element **(21.4B, 21.6B, 21.5B)** of the post-section-peripheral edge **(21)** of vehicle body **(20)** and
- the interlocking mating hole arranged in the outer door-contour-shaped auxiliary part **(6.5C)**.

20. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assembly includes

- an interlocking block **(31, 36)** rigidly attached to an auxiliary part **(6.6a, 6.8)** of window-guide element **(6, 6B)** and

– an interlocking mating hole arranged in the post section reinforced by a reinforcing element (23) and adjacent to that window-guide element.

21. An increased stiffness of vehicle structure according to claim **2**, wherein the adjustable interlocking assemblies of vehicle door **(8)** & post section operating in two planes are defined by

– bolting the interlocking blocks **(33, 34)** to a post section, reinforced by the reinforcing element **(23)**, having a striker **(298)** of latch mechanism **(248)** and

– disposing the interlocking mating holes to the window-guide element of vehicle door adjacent to that post section.

22. An increased stiffness of vehicle structure according to claim **21**, wherein the adjustable interlocking assembly includes

– the interlocking block **(33)** rigidly attached to the window-guide element **(6, 6B)** and

– the interlocking mating hole arranged in the post section, reinforced by the reinforcing element **23)**, having the striker **(298)** of latch mechanism **(248)** and adjacent to that window-guide element.

23. An increased stiffness of vehicle structure according to claim **21**, wherein the adjustable interlocking assembly includes

– the interlocking block **(34)** rigidly attached to an auxiliary part **(6.7a)** of the window-guide element **(6, 6B)** and

– the interlocking mating hole arranged in the post section, reinforced by the reinforcing element **(23)**, having the striker **(298)** of latch mechanism **(248)** and adjacent to that window-guide element.

24. An increased stiffness of vehicle structure according to claim **1**, wherein both ends of the stiff U-shaped window-guide element **(6, 6B)**, facing the lower vehicle part of vehicle body **(20)**, and an upper part of that window-guide element, facing the upper vehicle part of vehicle body **(20)**, receive the interlocking parts.

25. An increased stiffness of vehicle structure according to claim **24**, wherein the window-guide element **(6.4, 6.4B)** is rigidly attached to the respective stiff U-shaped window-guide elements **(6, 6B)**.

26. An increased stiffness of vehicle structure according to claim **1**, wherein the window-guides **(6.1, 6.2, 6.1B, 6.2B)** are rigidly attached to the respective stiff window-guide elements **(6.1a, 6.2a, 6.1aB, 6.2aB)**.

27. An increased stiffness of vehicle structure according to claim **1**, wherein two window-guides are rigidly attached to the stiff window-guide element **(6, 6B)**.

28. An increased stiffness of vehicle structure according to claim **1**, wherein the interlocking part comprising mechanical connection elements such as screw, rivet, washer, nut, pin, interlocking rings etc. and

– the interlocking hook **(15.6)** with interior diameter d_1 and gap s_1 or

– a sleeve **(15.11)** and washer **(15.13)** with outer diameter D in case of interlocking block,

is provided with a means to adjust the clearances between the mating interlocking parts from outside the vehicle.

29. An increased stiffness of vehicle structure according to claim **28**, wherein the front region of washer **(15.13)** has radial teeth.

30. An increased stiffness of vehicle structure according to claim **29**, wherein the washer is an integral part of a screw.

31. An increased stiffness of vehicle structure according to claim **28**, wherein the washer is an integral part of a screw.

32. An increased stiffness of vehicle structure according to claim **1**, wherein the sleeve **(15.11)** of interlocking part with exterior diameter d is governed by the equation $D \geq d \geq d_R$, where D is the exterior diameter of washer **(15.13)** and d_R is the diameter of spacer **(15.12)**.

33. An increased stiffness of vehicle structure comprising

a) a main vehicle body **(20)** having at least one door aperture **(20.1, 20.1B, 20.1T, 20.1x)** therein;

b) a mating vehicle door **(8, 8B, 8T, 8x)**, generally representing a tailgate- **(8T)**, sliding side-, cargo-, liftgate- and vehicle door **(8, 8B)**, whose stiff supporting door frame, defined by at least two stiff impact beams **(1, 7, 1B, 7B)**, stiff auxiliary parts and at least one stiff window-guide element **(6, 6B, 6.1, 6.2, 6.1B, 6.2B, 6.1a, 6.2a, 6.1aB, 6.2aB)** to guide and receive a window pane, is hingedly secured to that vehicle body **(20)** for pivotal movement between an open and a closed position;

c) interlocking assemblies, each of which including an interlocking part arranged to that door frame and an interlocking mating part to the vehicle body **(20)**;

d) adjusting mechanisms to adjust to clearances of adjustable interlocking assemblies, which are in engagement when the vehicle door is in a closed position;

e) wherein the interlocking assemblies of compound assembly of vehicle structure such as vehicle door & vehicle roof **(17)**, vehicle door & side rail **(18)**, vehicle door & post sections and/or vehicle door & peripheral edge **(21, 21T, 21x)** of vehicle body **(20)** operate in at least two planes in reference to the xyz global coordinate system of vehicle;

thus substantially ensuring the engagement of all compound assemblies, distributing impact energy to all vehicle parts of vehicle structure, lowering stress thereof and preventing passengers from being hurled out of the vehicle in the event of any real collision and/or rollover.

34. An increased stiffness of vehicle structure according to claim **33**, characterised by use of metal, compound material, glass fibre reinforced material or non-metal material for material of the interlocking part, window-guide element, auxiliary part, reinforcing element, transverse girder, reinforcing rod, plate, panel and U-shaped block.